RECENT PROGRESSES IN IN-SITU AND 3D HR-EBSD TECHNIQUES TO ASSESS DEFORMATION MECHANISMS OF MATERIALS AT SMALL SCALE

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Understanding deformation mechanisms of materials at the sub-micron scale requires advance characterization techniques capable of measuring microstructural changes, strains, stresses and lattice defects evolution during deformation. High angular resolution electron backscatter diffraction technique (HR-EBSD), coupled with SEM *in-situ* mechanical testing using a nanoindenter, is capable of characterizing all these features, with a sub-100nm resolution, at successive deformation steps and while the material is under load, making it ideal to study small-scale mechanics. However, HR-EBSD is a near surface technique, where only the first few tens of nm are probed underneath the surface. Surface effects are extremely important in small-scale mechanics and surface characterization might not be representative of what is going on in the material during deformation. 3D HR-EBSD technique has been developed to answer this issue and fully characterize the strains, stresses and crystal defect distributions in the deformed materials. Sub-100nm^3 voxel resolution can be achieved by applying successive FIB-slicing and HR-EBSD mapping. We applied this technique to study fracture mechanics in single crystal tungsten at different scales, strain rates and temperatures. The 3D defect distribution below the crack tip help understanding the brittle-to-ductile transition in this material. The results show that surface effects are more pronounced at low temperature.

A novel microtensile uniaxial set-up, equipped with a laterally compliant silicon gripper has been developed to overcome typical issues in small-scale tensile set-ups, particularly sample fabrication, sample handling and misalignment. Both gripper and specimen geometry has been optimized by FE modelling to replicate stress profiles comparable to macroscopic samples defined by ASTM 638. This system has been developed for *in-situ* HR-EBSD and used to study scale effects in twin initiation and propagation in single crystal magnesium. The results show that plastic deformation, with strong non-Schmid factor dislocation activities in the basal plane, occur before twinning at the micron-scale. Tensile twinning is rapidly followed by double twining mechanisms, with the development of compression twins in the middle of the tensile twin. The scale effect on single and double twins development will be discussed.